

pophyse aux vertèbres dorsales ni de fossettes apicales ; cependant le crâne de *G. tecpanecus*, dont j'ai figuré la seule partie que je possédais, ressemble plus à celui d'*Atractus* qu'à celui de *Geophis*. D'un autre côté les *Geophis* manquent de fossettes apicales et d'hypapophyses, quoique ils se rapprochent par leur ensemble du serpent en question ; de plus ils ont les dernières labiales supérieures en contact avec les pariétales, ce qui n'est pas le cas ici.

Il est donc évident que *G. tecpanecus* n'est ni un *Geophis* ni un *Atractus* ; mais comme il me paraît avoir des affinités avec les deux, je propose pour lui un genre nouveau, celui de *Geatractus*.

J'ai consulté à ce sujet une autorité en herpétologie, mon ami Mr. Boulenger, qui pense que ce genre est acceptable, et que c'est même un type fort intéressant, si peu de "Calamariens" étant pourvus de fossettes apicales.

4. Contributions to our Knowledge of the Plankton of the Faeroe Channel.—No. IV.¹ Report on the Copepoda collected by Dr. G. H. Fowler from H.M.S. 'Research' in the Faeroe Channel in 1896 and 1897. By ISAAC C. THOMPSON, F.L.S. (With an Appendix by Dr. FOWLER.)

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The material upon which this Report is based was collected in 34 out of the 41 hauls (omitting 12 *f*, the depth of which was not recorded). The Plankton had been immediately preserved in formalin, corrosive sublimate, or picric acid, and kept in 5% formalin. The Copepoda were picked out from the mass by Dr. Fowler, and sent to me in bottles labelled with the number of the station and letter of the haul whence the material was obtained.

By means of messengers in 1897 and of a screw-propeller in 1896 (see pp. 570-575), the mid-water tow-nets were opened and closed at will, enabling the depths to be almost accurately ascertained, the limit of error being dependent upon the possibly impeded rate of fall of the messenger or upon the accelerated rate of the screw-propeller in a very heavy sea.

The accompanying distribution table records the soundings, the depths at which the various hauls were taken, the temperature (Fahrenheit) at those depths, the number of meshes per inch of the net used, and the occurrences of each species. It will be seen that all the Copepoda collected are free swimmers, with one remarkable exception, that of *Argulus*, referred to later on.

The collection furnishes some interesting facts as to the influence of depth upon distribution. By far the commonest Copepod in the collection, and probably the most widely distributed species known, *Calanus finmarchicus*, occurs abundantly in 32 out of the 34 hauls,

¹ For Part I. see P. Z. S. 1896, p. 991 ; Part II., P. Z. S. 1897, p. 523 ; Part III., P. Z. S. 1897, p. 803.

and appears to be equally prevalent at all depths. But probably no other known species exhibits this ubiquitous feature to anything like the same extent. A reference to the distribution table will show that several species, such as *Heterochaeta abyssalis*, were not found at a less depth than 100 fathoms; while others, such as the well-known and beautifully coloured *Anomalocera patersoni*, usually remain about the surface, sometimes congregating in vast numbers.

The relative sizes of the same species at opposite depths is to a considerable extent seen in *Calanus finmarchicus*, the deep specimens being considerably larger than those found near the surface. Among our British Copepoda the largest known species is *Euchaeta norvegica*, but I am not aware that it has ever been taken in our waters at less than 80 or 100 fathoms, at which depth I have taken it in quantities in Loch Fyne, where it probably forms an important item in the diet of the herring.

The vertical distribution of Copepoda is doubtless to a considerable extent subject to climatic influences. During a continuance of stormy weather they often altogether desert the near surface and go very deep; while in fine warm weather many species love to gambol on the actual surface, presenting much the appearance of the "play" of the herring in miniature.

The size of mesh in the tow-net used is of considerable importance, and the apparent scarcity of such minute forms as *Oithona spinifrons* and *Ectinosoma atlanticum* is probably to be explained from the fact of a large mesh having been generally used; while the comparatively few tow-nets in which the above species were found were of a fine texture and probably might with advantage have been more generally employed.

Five out of seven species of Copepoda found by Dr. Brady in material from the Faeroe Channel (Exploration of the Faeroe Channel during the summer of 1880 in H.M.'s hired ship 'Knight Errant' by Staff-Commander Tizard, R.N., and John Murray) occur in this collection, viz.: *Eucalanus attenuatus*, *Centropages typicus*, *Anomalocera patersoni*, *Acartia longiremis*, and *Oithona spinifrons*.

The following species, viz., *Ætidius armatus*, *Euchirella pulchra*, *Heterochaeta abyssalis*, which occur sparingly in the collection, have never before been recorded north of the Mediterranean, this fact indicating a considerable extension of their distribution.

CALANUS HYPERBOREUS Krøyer.

A number of what I took to be specially large specimens of *Calanus finmarchicus* were found among the specimens from 20 d. Careful examination clearly proves them to be identical with *C. hyperboreus*, now recognized by Giesbrecht as a distinct species. The nipple-shaped lateral terminations of the cephalothorax, the large first abdominal segment, and the shape and position of the teeth on the basal joint of the 5th feet appear to be the chief points which separate *C. hyperboreus* from *C. finmarchicus*. Giesbrecht says that joint 19 of the anterior antennæ is as long as joints 23 and 24 together; but none of the very few specimens I found with

perfect antennæ agree with this description. Nor, curiously enough, does Giesbrecht's own exquisitely drawn figure (pl. vi. fig. 6, Pelagischen Copepoden des Golfes von Neapel &c.) bear it out.

Giesbrecht's grounds for making this a distinct species from *C. finmarchicus*, and not a mere variety, seem to me scarcely adequate. It is extremely likely that a species so widespread and living under so varied conditions should possess corresponding modifications such as we find here.

The very remarkable occurrence of three specimens of *Argulus foliaceus* in 15 *d* gathering is phenomenal; this species, so far as I am aware, having never been previously recorded except from fresh water, in which it is commonly found parasitic upon the stickleback, carp, and other fish. In this instance it appears to have been taken by the tow-net as a free-swimmer; and the only conclusion I can come to is that these three specimens became detached from a fish which had recently found its way into the sea from some stream. They in all particulars agree with *A. foliaceus*, differing markedly from any of the known marine species of *Argulus*.

[Notes to Table of Distribution.

- (1) Stations 11 to 19, 1896. Station 20, 1897.
- (2) The temperatures given for Station 20, hauls *a* to *d*, were not actually observed there, but are taken from the serial observations at Station 16; the difference between the two is probably trifling. The serial temperatures of the 1896 cruise are published in the Report of Proceedings &c. in the Faeroe Channel made by Capt. W. U. Moore, R.N., to the Hydrographic Office in 1896.
- (3) For the reason of the exclusion of *Calanus hyperboreus* from the table see p. 541.
- (4) VA=Very abundant. C=Common.
A=Abundant. F=Few.
S=Scarce.

G. H. F.]

Appendix to the foregoing Report. By G. HERBERT FOWLER, B.A., Ph.D., Assistant Professor of Zoology in University College, London.

Mr. Thompson's Report brings out some very interesting features, from the oceanographic standpoint, with regard to the distribution and bionomics of Copepoda. The most salient feature is, as he points out, the apparent indifference of *Calanus finmarchicus* to temperature and pressure. Like *Spadella (Krohnia) hamata*, discussed for the Faeroe Channel in an earlier paper of this series¹, and on a wider basis by Steinhaus² and Chun³, it is apparently equally happy whether at the surface under

¹ G. H. Fowler: Proc. Zool. Soc. 1896, p. 993.

² O. Steinhaus: Verbreitung der Chætognathen; Inaug. Dissert., Kiel, 1896.

Svo.

³ C. Chun: Beziehungen zwischen dem arktischen und antarktischen Plankton. Stuttgart, 1897.

pressure of 14 lbs., or at 500 fathoms under a pressure of half a ton, whether in bright light at a temperature of 54° F., or in utter darkness at a temperature of 30°-32° F. Not only so, but it ranges apparently all over the globe (although not in such quantity¹ as in the Arctic Seas), except for the fact that it has not been recorded for the Equator and the hottest parts of the tropics, nor south of Cape Horn. In the Antarctic regions according to Chun² its place is apparently taken by *Calanus propinquus*; but Mr. Thompson informs me by letter, that in a recent examination of Antarctic Plankton he finds *Calanus finmarchicus* to be one of the commonest species. Its general distribution is cited by Giesbrecht³.

In discussing the Plankton of the Faeroe Channel it must be remembered that we are dealing with a 'Mischgebiet,' for which I would suggest the term 'Frontier,' a district in which the North-easterly continuation of the North Atlantic Drift (the so-called Gulf Stream), carrying a warm-water fauna, is constantly warring with a Southerly set of Arctic water carrying a cold-water fauna⁴. Both in 1896 and 1897 a succession of north winds had given a distinctly northern character to the fauna; and although, for example, *Ianthina*-shells and *Physophora hydrostatica* have in some cases been swept by the North Atlantic Drift as far north as the Lofoten Islands through the Faeroe Channel, I have not so far come across a single characteristically warm-water surface species in the 'Research' collections of either year from the Faeroe Channel.

Taking now the 34 hauls in which Copepoda were captured, we have 17 Epiplankton⁵ hauls of less than 100 fathoms, and 13 Mesoplankton⁵ hauls (including 12*a*, in which the depth was not so approximately known as in the other deep hauls, but which

¹ With the view of testing the Prince of Monaco's suggestion, that a tow-net could be made to provide food for shipwrecked boat's crews, we tried this species, raw, in the ward-room of the 'Research.' The Officers voted it excellent food, like "delicate shrimp-paste"!

² C. Chun, *op. cit.* p. 48.

³ W. Giesbrecht: Pelagische Copepoden des Golfes von Neapel, 1892, p. 89.

⁴ Compare Chun, Beziehungen zwischen d. arktischen u. antarktischen Plankton, pp. 7-10. Stuttgart, 1897. 8vo.

⁵ In my lectures on Oceanography at University College, I have felt the need of simple terms to express briefly the Oceanic zones, and have used the following:—

Epiplankton: 0 to \pm 100 fathoms below surface.

Mesoplankton: \pm 100 fathoms below surface to \pm 100 fathoms above bottom.

Hypoplankton: \pm 100 fathoms above bottom to bottom.

Epibenthos: high-water mark to the mud-line (generally at \pm 100 fathoms depth) = fauna of the continental shelf.

Mesobenthos: the mud-line (\pm 100 fathoms) to \pm 500 fathoms = fauna of the continental slope.

Hypobenthos: over \pm 500 fathoms = abyssal fauna.

This is not the place in which to discuss the justification of these terms: their intention will be apparent to all who have followed the recent progress of oceanic zoology. Two of them may be queried:—(1) the Hypoplankton, under which I reckon those floating and swimming animals (Crustacea, Fish, &c.) which, for nutrition and for other reasons, are more intimately connected with

certainly finished below the 100 fathoms), in all 30 hauls, with which to deal. Regarding, then, only those species which were captured six times, or in 20 % of the hauls, as affording a sufficient basis for discussion, we find that the occurrences of seven species work out thus, expressed in percentages of hauls made above and below 100 fathoms :—

	Epiplankton.	Mesoplankton.
<i>Calanus finmarchicus</i>	88.2 %	100.0 %
<i>Eucalanus attenuatus</i>	17.6 "	46.1 "
<i>Euchaeta norvegica</i>	11.7 "	76.9 "
<i>Metridia longa</i>	23.5 "	69.2 "
<i>Pleuromma abdominale</i>	5.8 "	61.1 "
<i>Acartia clausii</i>	35.2 "	15.3 "
<i>Temora longicornis</i>	35.2 "	0.0 "

From this table it would appear (1) that *Calanus finmarchicus* is essentially eurythermal and eurybathic, *i. e.* has a wide range both of temperature and of depth; (2) that *Eucalanus attenuatus*, *Euchaeta norvegica*, *Metridia longa*, and *Pleuromma abdominale* show a distinct preference for the deep water and low temperature of the Mesoplankton, although occurring more sparingly in the Epiplankton; (3) that *Acartia clausii* belongs rather to the Epiplankton than to the Mesoplankton; (4) that *Temora longicornis* is essentially a member of the Epiplankton. We may now compare these results, based unfortunately on but scanty data, with those recorded by others.

In the first place, *Calanus finmarchicus*, as mentioned above, has been recorded from most varied temperatures (latitudes), and is now definitely shown to extend to considerable depths (Sta. 18 *b*, 530–400 fm.). It does not occur among the Mesoplanktonic forms in Giesbrecht's list (*op. cit.* p. 788), and its vertical distribution in the Faeroe Channel is therefore worth recording. It is not at present safe to suggest a maximum temperature, as expressed by mean annual isotherms, for this species; it is, however, possible that its non-occurrence in the Equatorial region may indicate a maximum of 75° or 80° F. as its temperature limit.

In the second place, it is noteworthy that of the five species of Copepoda recognized by Chun¹ as essentially Arctic types (Leitformen), one is missing from the 'Research' collections (*Calanus cristatus*); one, regarded by Mr. Thompson as a species of doubtful

the bottom than with the Mesoplankton; (2) the Mesobenthos, which seems on statistical and other grounds to have certain marked features, both faunistic and physical, which distinguish it from the zones below and above it; although it shares many species with other zones, still, according to the 'Challenger' results (J. Murray, Summary of Scientific Results, Exped. H.M.S. Challenger, part ii. p. 1430, table 1), no less than 74 per cent. of its fauna is confined to it, and does not spread into other zones.

These six words, with the addition of the terms "oceanic" and "neritic" as applied respectively to the plankton of the open ocean and of the continental region, have been found in practice to serve sufficiently well for descriptive purposes.

¹ C. Chun, *op. cit.* p. 28. His list is a condensation from that of Giesbrecht, *op. cit.* pp. 776–7.

value, occurred rarely (*C. hyperboreus*); one, *Pseudocalanus elongatus*, is only represented three times, and cannot therefore be further discussed; two, *Metridia longa* Lubbock (= *armata* Boeck) and *Euchaeta norvegica*, are well represented. Both of these species exhibit, in the table of percentages above given, that preference for a mesoplanktonic existence which one would expect of an Arctic species in a Frontier district. For if the law be true, which was enunciated first, I think, by Moebius, that the area of distribution of a Planktonic organism is bounded at the surface by an isotherm and below by an isothermobath of the same number of degrees, we should expect Arctic forms to sink to lower (colder) depths as they approached lower latitudes (warmer surface-water). The southernmost points recorded in Giesbrecht's lists for these two species at the surface are—the northern part of the North Sea for *Euchaeta norvegica*, and Concarneau for *Metridia longa*. We are probably safe in assigning a maximum mean annual temperature¹ of 50° F. for *Metridia longa*, and a slightly lower mean annual for *Euchaeta norvegica*. In the very interesting collections made by Prof. Herdman in his traverse of the North Atlantic², the eight captures of *Metridia longa* were all near the mean annual isotherm of 50° F.; *Euchaeta norvegica* was not captured at all. As regards the vertical distribution of *Euchaeta norvegica*, the Norwegian North Atlantic Expedition failed to capture this species at the surface³, but it certainly comes to the surface in the Faeroe Channel, even in broad daylight (Sta. 11 c).

The other two forms, which, according to the table of percentages given above, exhibit an apparent preference for the Mesoplankton—*Eucalanus attenuatus* and *Pleuromma abdominale*,—are united in having a very wide superficial range in the Atlantic and Pacific Oceans; both occur in Giesbrecht's list of mesoplanktonic Copepoda, *Eucalanus attenuatus* being credited with 1000 m. = ± 550 fms., *Pleuromma abdominale* with 4000 m. = ± 2200 fms. Both these species must be regarded as eurythermal and eurybathic; and it is not at present possible to suggest a maximum or minimum temperature for either of them. Their apparent preference for the Mesoplankton in my collections must therefore be attributed to some other cause than temperature; but it is in no way inconsistent with what we already know of their habits.

Temora longicornis appears to be confined to the North Atlantic, except for two records from the Mediterranean which Giesbrecht appears to doubt⁴. So far as I am aware, it has never been recorded from any considerable depth, and with this my results accord: we may fairly regard it as a member of the Epiplankton;

¹ The mean annual temperatures are adopted from Buchan, Chall. Rep. Phys. Chem. ii. Atmospheric Circulation.

² W. A. Herdman, I. C. Thompson, and A. Scott: Trans. Liverpool Biol. Soc. xii. 33.

³ G. O. Sars: Crustacea of the Norwegian N. Atlantic Expedition, i. p. 240.

⁴ W. Giesbrecht, *op. cit.* pp. 328-330. Mr. Thompson informs me by letter that this species occurs also in a collection made at Muscat by Staff-Surgeon Bassett-Smith, R.N., of H.M.S. 'Cossack.'

and if it occurs between Newfoundland (mean annual isotherm 35° F.) and Muscat (mean annual isotherm 80° F.), it is remarkably eurythermal for an epiplanktonic animal.

As Mr. Thompson has mentioned, the occurrence of *Euchæta marina* so far north is remarkable. It has been recorded hitherto, according to Giesbrecht and Brady, in both Atlantic and Pacific Oceans, northwards from 47° S. (?) across the tropics, but with a northern limit in the Mediterranean. In Giesbrecht's list of mesoplanktonic species, it figures as from 4000 m.=2200 fms. to the surface. According to Brady¹, "it would seem to be the most abundant and most widely distributed of all the pelagic Copepoda," a description which it deserves more than ever, now that its range has been extended to the Faeroe Channel. In Prof. Herdman's traverse it was "found in the majority of the collections taken between mid-ocean and Quebec," *i. e.* across the mean annual isotherms of 35° to 50° F. Its extension northward in our longitudes is therefore by no means surprising.

The occurrence of *Euchæta barbata* and *Euchæta gigas* in the Faeroe Channel is most extraordinary. Both species have hitherto been taken only once, and then only together, *viz.* off Buenos Ayres (Challenger Sta. 325, 36° 44' S., 46° 16' W., down to 2650 fathoms). Their reappearance, still together, in northern latitudes makes it fairly safe to prophesy that the use of deep-water tow-nets in intermediate latitudes will prove them to be mesoplanktonic species of wide distribution.

Euchæta hessei (G. S. Brady), which, as Giesbrecht suggests, is perhaps identical with *Euchirella rostrata* (Claus), is known sparingly from both Atlantic and Pacific Oceans; its distribution is considerably extended by its occurrence in the 'Research' collections.

Euchirella pulchra has been recorded, according to Giesbrecht, only from the Gulf of Guinea, N.W. Africa, and South America. *Paenna spinifera*, *Leuckartia flavicornis*, and *Heterochæta spinifrons*, according to the same authority, are known only from the Mediterranean (including the Canaries) and from the tropical Pacific; only the last of these occurs among the species taken in Prof. Herdman's traverse of the Atlantic; their range is now extended northwards to the Faeroe Channel. They illustrate well how impossible it is at present to draw distributional areas for most Copepoda; this group of Crustacea will probably rival the Radiolaria in the width of its distributional areas, owing to the hardiness and tenacity of life of many of its members. But—if we bear in mind that this is a Frontier district, *i. e.* one where a heavy slaughter of the Plankton occurs at the meeting of warm and cold currents, as is evinced by the abundant formation of glauconite and phosphatic nodules in the bottom deposits², and by the wealth of the benthos,—

¹ G. S. Brady, Chall. Rep. Zool. viii. Copepoda, p. 62 (*Euchæta prestandree*).

² For the glauconite, see Tizard and Murray, Proc. Roy. Soc. Edinburgh, i. pp. 671 *et seqq.*—"There were no very large phosphate nodules, but numerous small ones, with phosphates in varying quantities," in a letter from Sir John Murray.

it is not a little suggestive that the above four species (to which may perhaps be added *Euchaeta hessii* and *Candace truncata*), which appear to have wandered north of their usual habitat, were only taken in the 'Research' from the Mesoplankton, and in all cases marked by Mr. Thompson as "Scarce." All six occurred once only, except *Euchaeta marina*, which was captured twice. It seems at any rate possible that these wanderers had either been killed by a reduced temperature, or at any rate so numbed by cold as to be gradually sinking to the bottom.

Acartia clausii of Giesbrecht has been separated by that author from *A. (Dias) longiremis* of Lilljeborg; he uses the latter specific name for species from the Baltic and Sound only. Assuming his view to be correct, the area of *A. clausii* has been somewhat extended northwards by the 'Research' collections: it reaches southwards to the Canary Islands, including the Mediterranean. I gather, however, from Mr. Thompson that he himself would prefer to regard the Baltic and North Atlantic forms as varieties of one species.

A. clausii appears to have been known hitherto as an epiplanktonic form only¹. Possibly its occurrence in deep water, at Station 20, may be due to dead or numbed specimens sinking from the surface; but it was so regular in its appearance on that occasion (in three out of four mesoplankton hauls), that, if the above explanation be correct, a very large swarm of this species must have succumbed to cold recently. As it did not occur in my mesoplankton hauls in 1896, I should prefer to leave the question open.

Rhincalanus cornutus and *Aetidius armatus* have been sparingly recorded from both Atlantic and Pacific Oceans, but not, so far as I know, from as far north as the Faeroe Channel.

As regards the remaining species in Mr. Thompson's list, there does not appear to be anything of mark connected with their appearance in the 'Research' collections, with the exception of *Argulus* (cf. p. 544).

The following conclusions as to vertical distribution appear to be justifiable on a comparison of the 'Research' collections with other records:—

Calanus finmarchicus is eurythermal and eurybathic.

Metridia armata and *Euchaeta norvegica*, two essentially Arctic types, tend to descend to the Mesoplankton on reaching lower latitudes.

Eucalanus attenuatus and *Pleuromma abdominale* are apparently eurythermal and eurybathic.

Temora longicornis and *Anomalocera patersoni* are apparently confined to the Epiplankton.

¹ F. Dahl, Verhandl. deutschen zool. Gesellsch. 1894, p. 64.